Evaluation Periods and Asset Prices in a Market Experiment

URI GNEEZY, ARIE KAPTEYN and JAN POTTERS[*]

ABSTRACT

We test whether the frequency of feedback information about the performance of an investment portfolio and the flexibility with which the investor can change the portfolio influence her risk attitude in markets. In line with the prediction of myopic loss aversion (Benartzi and Thaler (1995)), we find that more information and more flexibility result in less risk taking. Market prices of risky assets are significantly higher if feedback frequency and decision flexibility are reduced. This result supports the findings from individual decision making, and shows that market interactions do not eliminate such behavior or its consequences for prices.

IN FEBRUARY 1999, BANK HAPOALIM, Israel's largest mutual funds manager, announced that it intended to change its information policy towards its client–investors. The bank would send information about the performance of its funds not every month as it had in the past, but rather only once every three months. Clients would still be able to check the performance every day if they chose, but if they did not, they would get the information less frequently than before. The bank expected investors to be more willing to hold assets in the mutual fund when they are less frequently informed about the evolution of fund prices. The bank's argument was that "investors should not be scared by the occasional drop in prices."[1]

The bank's argument corresponds closely to the concept of myopic loss aversion (MLA) advanced by Benartzi and Thaler (1995). As the name suggests, MLA combines two behavioral concepts: myopia and loss aversion. Loss aversion, introduced by Kahneman and Tversky (1979), refers to the tendency of individuals to weigh losses more heavily than gains. Myopia, in this context, refers to an inappropriate treatment of the time dimension. For example, bad news from one day to the next ("the market value of an investment fell since yesterday") is treated in

[1] See the newspaper Yediot Hachronot, February 16, 1999 (in Hebrew).

the same way as bad news referring to a longer period ("the market value of an investment fell since last year").

When investors myopically evaluate their portfolio at high frequencies, say every day, there will be many days during which the return on investment in the stocks will be lower than the return on investment in bonds or savings accounts. On the other hand, if they evaluate the performance of the investment in stocks less frequently, it is more likely that the aggregate return on the investment is positive, and larger than that in bonds. Since losses weigh more heavily than gains, the frequent comparisons of returns on bonds or savings accounts with the returns on stocks will lead to "disappointment" about the performance of the investment in stocks. When considering performance over longer periods, the stocks are more likely to outperform the bonds or savings accounts, and, hence, investors attach a higher valuation to the stocks.

MLA can be illustrated with a simple example. Suppose an individual has $100 to invest. He can either put it in a savings account with zero interest or he can invest in a risky stock that yields a net return of $200 with probability $\frac{1}{2}$ and $-$100 (i.e., he loses his money) with probability $\frac{1}{2}$. Assume the individual is loss averse and has a utility function $u(z) = z$ for $z > 0$ and $u(z) = \lambda z$ for $z \leq 0$, where z is the change in the portfolio value, and $\lambda > 1$. We call λ the loss aversion parameter. For this illustration take $\lambda = 2.5$. Given this utility function, the expected utility of investing in the stock is negative: $\frac{1}{2}(200) + \frac{1}{2}(-250) < 0$. Imagine the same individual is offered the opportunity to invest $100 in two consecutive periods, where in both periods the stock gives a net return of $200 with probability $\frac{1}{2}$ and $-$100 with probability $\frac{1}{2}$. The individual will now choose to invest $100 in the stock in each period if he evaluates the investments in combination: $\frac{1}{4}(400) + \frac{1}{2}(100) + \frac{1}{4}(-500) > 0$. If, however, the investment is evaluated for each period separately, the individual will not invest in the stock. The example illustrates that loss-averse investors will find risky assets less attractive if they evaluate them over a shorter time horizon.

Benartzi and Thaler (1995) advance MLA as a potential explanation for the well-known equity premium puzzle. Over the last century, the average real return of stocks in the United States has been about six percentage points per year higher than that of bonds (Mehra and Prescott (1985)). Benartzi and Thaler perform a simulation in which they use the stochastic process that corresponds to the historical pattern of stock and bond returns, and choose parameter values for the utility function, including the loss-aversion parameter, based on the cumulative version of prospect theory (Tversky and Kaheneman (1992)). They find that the equity premium puzzle can be resolved if it is assumed that investors evaluate their portfolios at roughly annual frequencies.

Benartzi and Thaler's (1995) analysis is a purely theoretical one, but recently some experimental evidence in support of MLA has become available. For example, in Thaler et al. (1997), experimental subjects allocate their investments to two funds, one with a relatively high mean and variance of returns and one with a relatively low mean and variance. The experiment manipulates the evaluation period of the subjects. In a "monthly" treatment, subjects make 200 investment decisions, each binding for one period, and are updated on returns after each

period. In a "yearly" treatment, subjects make 25 investment decisions, each binding for eight periods, and are updated on (aggregated) returns after each eight-period interval. In line with MLA, Thaler et al. find that subjects in the yearly treatment hold significantly more assets in the risky fund than subjects in the monthly treatment. Barron and Erev (2000) and Gneezy and Potters (1997) obtain similar experimental results.[2]

Although these experimental results provide some direct evidence for MLA, they are concerned with individual decision-making rather than market interaction. Each participant makes her own independent decisions but these have no effect on the decisions of other participants or vice versa. Stocks and bonds, however, are traded in markets. An essential feature of markets is that the marginal traders determine prices. As a consequence, individual violations of standard expected utility theory do not necessarily imply that market outcomes will violate expected utility theory.[3] A small number of rational agents may be enough to make market outcomes rational. Another important issue is that market interaction will affect individuals' experience and information feedback. The learning process in repeated individual decision tasks will be different from the learning process in repeated market interaction. Traders can learn from observing the choices of other traders and from the information contained in prices. Hence, there are a number of reasons to question whether phenomena that are observed in individual decision making will carry over to market interaction.

The current paper aims to test whether the effects of MLA will also show up in a competitive environment. We set up experimental markets in which traders adjust their portfolios by buying and selling a risky financial asset. In the "high-frequency" treatment, traders commit their investments for one period, and are informed about the assets' returns after each period. In the "low-frequency" treatment, they commit their investments for three periods, and are informed about the assets' returns only after three periods.

We find that prices of the risky asset in the low-frequency treatment are significantly higher than in the high-frequency treatment. These results are in line with the results of the individual choice experiments. Investors are more willing to invest in risky assets if they evaluate the consequences in a more (time-) aggregated way. In our market experiment, this shows up as a positive effect on prices.

Although the structure of our experiment allows us to test the predictions of MLA in markets, it may appear to differ from actual markets in an important way. In most financial markets today, information is available in virtually continuous time. The decisions traders and investors make about how often to sample

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[2] However Langer and Weber (2001, 2002) argue that MLA is not as general and robust. They term the alternative they provide "Myopic Prospect Theory."

[3] Enke (1951) provides the classic argument for why the assumption of rationality may be a good approximation of behavior of agents in markets, but not necessarily of the description of individual behavior. Forsythe et al. (1992) provide an example of an asset market in which performance depends not on the average biased trader, but on the unbiased marginal trader who consistently buys and sells at prices very close to the equilibrium price. See Camerer (1992) for a more comprehensive discussion of the potential of markets to correct anomalous individual behavior in experiments.

that information and how often to trade are endogenous. There are at least two considerations worth pointing out in this regard. First, the distinction in the experimental setup between the high-frequency and low-frequency treatments lies not only in the frequency of information feedback, but also in the length of the period during which investments are committed. Our experimental results tell us that if investments are committed over longer periods, risky assets become more attractive as reflected by a higher market price. Thus, it is not just the speed at which information is available that drives the price differences between the high-frequency market and the low-frequency market, but also the frequency at which decisions can be or will be made. As Benartzi and Thaler (1995) point out, for various agents, there are natural intervals over which decisions will be made and evaluated. For fund managers, the decision period may coincide with the period over which performance reviews take place, for example, a year. For individual investors, such a period may coincide with statements sent to them by banks or pension funds (particularly for defined contribution plans). But a decision may also be triggered by other institutional arrangements, for instance the need to consider and perhaps rebalance one's portfolio for tax purposes.

Secondly, although one can follow stock prices on a continuous basis, information provision is not continuous. Firms, or other organizations, only infrequently divulge information that may impact stock prices. Our results suggest that the frequency with which firms provide information may affect the price of their stocks.

Our experiment reveals an unambiguous effect of the length of the period over which investments are committed on the equilibrium price. If this finding is replicated in other experiments and by research based on field data, it may have profound implications for the way we model prices in financial markets.

In Section I, we outline the experimental design and procedure. In Section II, we present the experimental results. We discuss the results in Section III. Section IV gives our conclusion.

I. Experimental Design and Procedure

We set up a market in which eight participants can trade units of a risky asset in a sequence of 15 trading periods.[4] Each unit of the asset is a lottery ticket, which, at the end of a trading period, pays 150 cents with probability $\frac{1}{3}$, and 0 cents with probability $\frac{2}{3}$. At the beginning of each period, a trader is endowed with a cash balance of 200 cents and three units of the asset. If a trader buys a unit, the price is subtracted from her cash balance, and one unit of the asset is added to her portfolio. If a trader sells a unit, the price is added to her cash balance and a unit is subtracted from her portfolio.

At the end of the period, the asset expires and its value is revealed through a lottery. Each trader's earnings for the period are equal to: 200+[prices received

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[4] The number of eight traders was chosen since usually a number of eight traders appears to be sufficient to obtain competitive outcomes. The number of 15 rounds should be enough to allow for learning, but not so large that marginal incentives per round become negligible.

for units sold] − [prices paid for units bought] + [number of units in portfolio at the end of the period] × [value of the asset (0 or 150) as determined by the lottery]. These earnings are transferred to a trader's accumulated earnings, and the next period starts with each trader again having a portfolio consisting of 200 cents in cash and three units of the asset. Traders cannot use accumulated earnings from earlier rounds to buy assets.[5]

There are two different treatments. In the "high-frequency" (*H*) treatment, the market opens in each of the 15 periods of the experiment, and in each period, traders can adjust their portfolio by buying and selling units, as described above. At the end of each period, traders are informed about the realized value of the asset for that period, and then the next period starts. In the "low-frequency" (*L*) treatment, the market opens for trading only in the first period of a block of three periods, that is, trading takes place only in periods 1, 4, 7, 10, and 13. In each of these trading periods, units are traded in blocks of three. If a unit is bought (sold) at a particular price in period *t*, then a unit is also bought (sold) at that same price in periods *t*+1 and *t*+2. Traders fix their asset holdings for three periods. After trading period *t* is over (with *t* = 1, 4, 7, 10 or 13), three independent draws determine the values of the units in periods *t*, *t*+1 and *t*+2, respectively. Traders are informed about the three realized values simultaneously. For example, they may learn that the values of the asset in the three periods are 0, 0, and 150, but these three values are not explicitly assigned to a particular period.

The two treatments aim to manipulate the period over which participants evaluate outcomes, in almost exactly the same way as in the individual choice experiments of Thaler et al. (1997) and Gneezy and Potters (1997). Since the frequency of portfolio adjustment and information feedback is lower in treatment *L*, the participants in this treatment are expected to evaluate the financial consequences of holding units in a more aggregated way than the participants in treatment *H*. If agents are myopic, the horizon in treatment *L* may be three periods, whereas in treatment *H* it will be one period. As we will argue next, such myopia induces loss-averse traders to be less willing to hold assets, and leads to lower prices of the risky asset in treatment *H* than in treatment *L*.

Suppose there are only three periods, and in each period, one asset can be bought. At the end of a period, the asset expires and pays 0 with probability $\frac{2}{3}$ and 150 with probability $\frac{1}{3}$. Let a trader be characterized by a utility function $u(z) = z$ for $z > 0$ and $u(z) = \lambda z$ for $z \leq 0$, where z is the change in wealth and $\lambda > 1$. Assume that the asset trades at a price p, with $0 < p \leq 50$. If the trader evaluates the purchase decision for each period separately, then with $0 < p \leq 50$, she will be indifferent between buying and not buying an asset in a period if $\frac{1}{3}(150 - p) + \frac{2}{3}\lambda(-p) = 0$, that is, if $p = p_H \equiv \frac{150}{1+2\lambda}$. Now assume the trader evaluates the investment in the asset over three-period intervals, that is, she considers
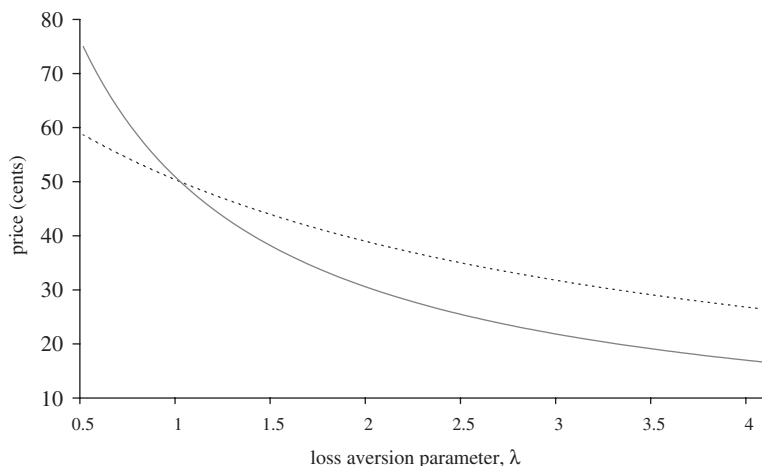
Figure 1. Equilibrium prices as a function of loss aversion. The plots show the prices at which traders with loss aversion λ are indifferent between buying and not buying the risky asset. The steeper curve refers to traders who evaluate period-by-period (p_H), the flatter curve refers to traders who evaluate three periods in combination (p_L).

buying an asset either in three consecutive periods or in none of the periods. With $0 < p \leq 50$ she will be indifferent between buying and not buying an asset in each period if $\frac{1}{27}(450 - 3p) + \frac{6}{27}(300 - 3p) + \frac{12}{27}(150 - 3p) + \frac{8}{27}\lambda(-3p) = 0$, that is, if $p = p_L \equiv \frac{1350}{19 + 8\lambda}$.

Figure 1 shows p_H and p_L as functions of λ. The steeper curve is the graph of p_H. Note that $p_L > p_H$ if and only if $\lambda > 1$. To the extent that our two treatments are successful in manipulating the "mental accounts" of the traders, MLA would predict higher prices in treatment p_L than in treatment p_H.[6]

Standard expected utility theory would predict more flexibility to lead to more risk taking. A proposition proved by Gollier, Lindsey, and Zeckhauser (1997) is relevant. In the present context, the proposition implies that whenever an investor who is restricted to fix his portfolio for several periods prefers to buy the risky asset, then surely the investor will buy the risky asset in the first period (at the same price) if he has the flexibility to adjust his portfolio over time. According to expected utility theory, we should expect the market price of the asset in the first period to be at least as high in treatment H as in treatment L ($p_H \geq p_L$).

Ten experimental sessions were run, five for each treatment. The experiment was conducted using the computerized labs of Tilburg University (two sessions in each treatment) and the University of Amsterdam (three sessions in each treatment). Eight subjects participated in each session, except for one session in which we had seven traders. No subject participated more than once. Undergraduate

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[6] A qualitatively similar prediction would obtain if we were to define the low frequency treatment as one where an investment is committed for only two periods rather than three. By imposing commitment for three periods, it is more likely that we will obtain statistically significant results if the MLA explanation is correct.

students were recruited as subjects through announcements in class and in the university newspapers.

Upon entering the lab, a short introduction was read by the experimenter to the subjects. By drawing table numbers, the subjects were randomly seated behind computer terminals, separated by partitions. Instructions (see Appendix) were distributed and read aloud. Subjects could examine the instructions more carefully and privately ask questions. During the experiment, all amounts were denoted in cents, with 100 cents being equal to 1 Dutch guilder. A Dutch guilder exchanged for US$0.54 at the time of the experiment.

Trading took place according to double auction rules. Traders could submit bids to buy and offers to sell. All traders were instantaneously informed about all bids and offers submitted to the market. At any time during a trading period, traders could decide to buy at the lowest offer or to sell at the highest bid. When a unit was traded, the accepted bid or offer was withdrawn from the market and all traders were informed that a trade had occurred at that price. Units traded one by one, that is, all bids and offers were for one unit only. Traders could submit as many bids and offers to the market as they liked, and sell and buy as many units as they liked. Traders could not sell when they had no units in their portfolio, and they could not buy when their cash balance was insufficient. Also, an individual improvement rule was enforced, requiring a new offer (bid) price to be lower (higher) than that trader's standing offer (bid).

A trial period in which participants could practice with the market rules was held before the 15 periods of the experiment were started. A trading period lasted three minutes in the H treatment and four minutes in the L treatment.[7] In treatment H, a lottery was conducted at the end of each trading period. To determine whether the asset paid 0 cents or 150 cents in a period, we used a box containing three disks: two blacks and one white. The outcome of the lottery was determined by drawing one disk out of the box. If the disk drawn was black, the value of all units for that period was 0, and if it was white, the value was 150 cents. The disk drawn was shown to the participants and the value was entered in the computer. In treatment L, the value of the asset must be determined for three consecutive periods. We used three boxes, each containing two black disks and one white disk. One disk was drawn from each of the boxes, and these three disks determined the values of the units in the three periods. Participants were informed about the realizations of the three lotteries simultaneously and without learning which draw corresponded to which period. In either treatment, after the value of the units was determined, subjects' earnings for the previous period (or previous three periods) were determined. Then the next trading period started. At the end of period 15, subjects were privately paid their accumulated earnings. Earnings averaged 65 Dutch guilders (about $35).

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[7] Treatment L had five trading periods, whereas treatment H had 15. We extended the trading time in the L treatment by one minute in order to make the total time for a session in the two treatments more similar. It is clear from the data that three minutes was more than enough for all the intended trades to be completed without any time pressure.

II. Results

Figure 2 presents the transaction prices in each of the 10 sessions of our experiment. Recall that trading in treatment *L* takes place for blocks of three rounds 1–3, 4–6, 7–9, 10–12, and 13–15. Prices are volatile in the early rounds of some of the sessions. See in particular session four (treatment *L*) and session nine (treatment *H*). In the early rounds, prices range from a low of 20 to a high of 150. Clearly, some
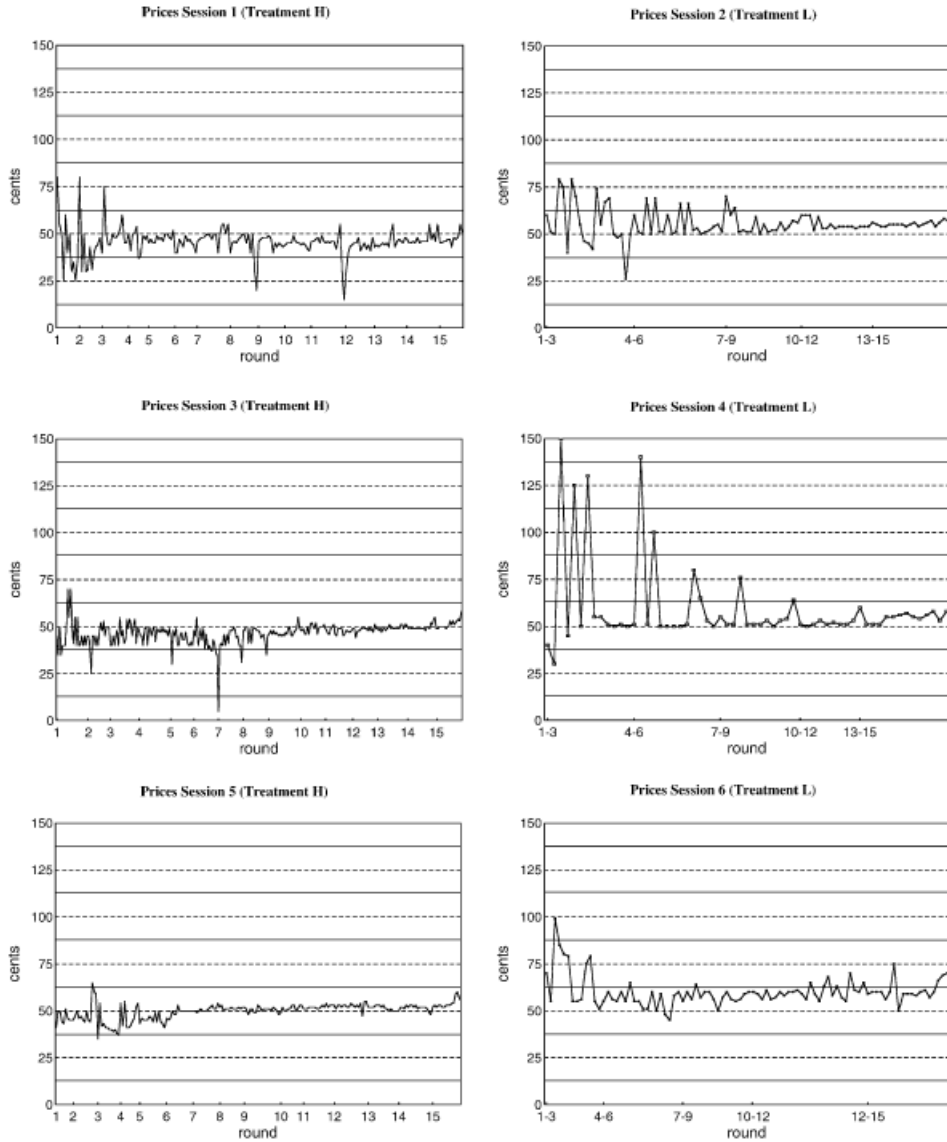

Figure 2. Asset prices per session. For each session, the prices of all transactions are displayed.
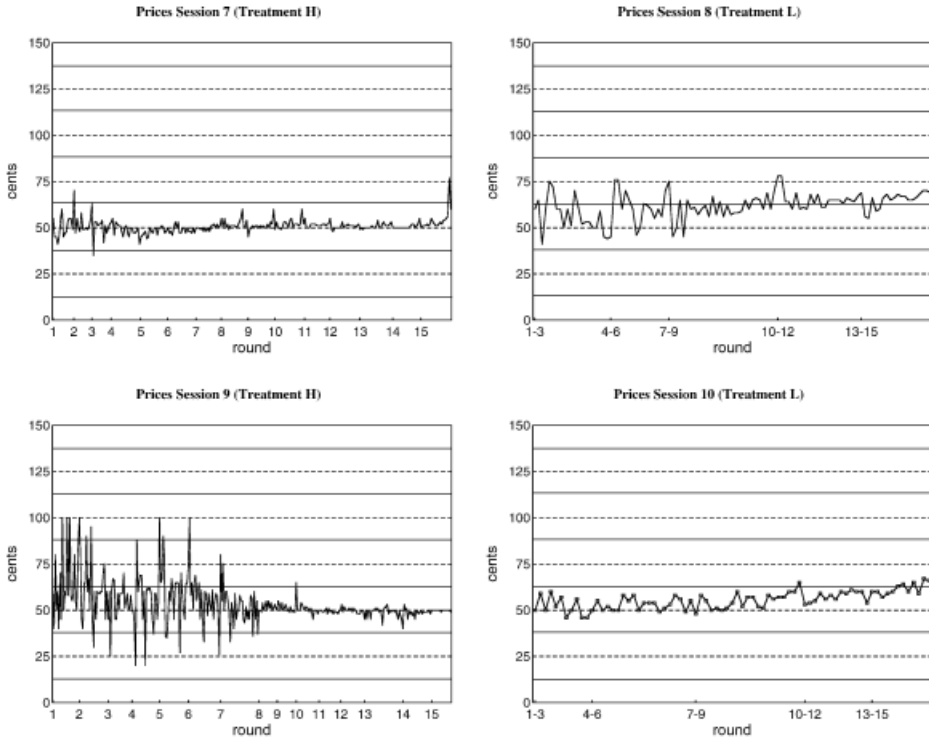
Figure 2—*continued*

subjects have to learn the expected value of holding assets. They may initially buy at too high a price or sell too low. In most of the sessions prices stabilize fairly quickly.

To test the basic hypothesis $(p_L > p_H)$ we compare the transaction prices of the asset in the two treatments. Figure 3 presents the evolution of average prices over the rounds for each of the treatments. Table I summarizes the relevant data and statistical tests. For each block of three rounds, average prices are presented for treatment H and treatment L, respectively. The final row presents the average transaction price across all rounds.

The results display a clear treatment effect in the direction predicted by MLA. In all rounds, average transaction prices are lower in treatment H than in treatment L. Across all rounds, the assets' average price is 49.3 in treatment H and 58.4 in treatment L. This difference is significant at $p = 0.01$ with a two-tailed Mann–Whitney U-test, taking the 10 session averages as units of observation. Table I also shows that the average standard deviation of prices is smaller in treatment H (4.7) than in treatment L (7.7). This difference is not significant ($p = 0.33$) due to substantial differences in the variability of prices across sessions (see Figure 2).

Apart from the difference in average prices, the aggregate data are very similar across the two treatments. The first row of Table II displays the average realized
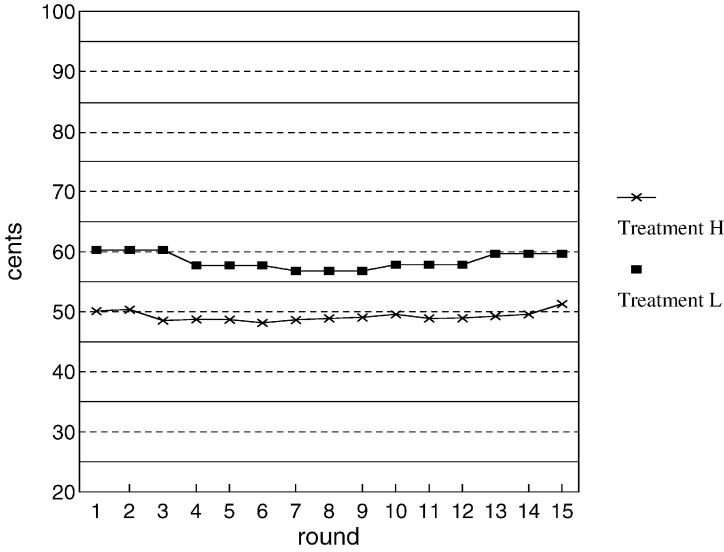
Figure 3. Average prices per round. For each round, asset prices are averaged first over the transactions in a session, then over the five sessions of each treatment.

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Table I

Average Prices per Block of Three Rounds

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This table reports average prices of the risky asset in each block of three rounds. Standard deviations are in parentheses. Averages and standard deviations are calculated for the prices within a round and then averaged over the rounds and sessions. The final column gives the significance levels of Mann–Whitney tests for the difference between treatments with the 10 experimental sessions as units of observations.

rounds	treatment H	treatment L	p-value
1–3	49.7 (9.4)	60.4 (16.6)	0.06
4–6	48.6 (5.8)	57.6 (10.3)	0.06
7–9	48.9 (3.7)	56.8 (5.4)	0.01
10–12	49.3 (2.4)	57.6 (3.0)	0.03
13–15	50.1 (2.2)	59.6 (3.4)	0.01
all rounds	49.3 (4.7)	58.4 (7.7)	0.01

value of the asset. The traders in treatment H were a bit luckier with an average asset value of 58.0 compared to treatment L where the average asset value was 48.0. The difference is not statistically significant. The second row indicates that the average number of assets traded per round per trader is almost identical for the two treatments. Our manipulation only affected the price level and not the average willingness to trade. Also the posttrade distribution of assets across traders is very similar for the two treatments. For example, for each session, we computed the standard deviation of the final number of assets held across traders.

Table II
Asset Value, Number of Trades, and Allocation of Assets

This table gives, for each treatment, the average value of the risky asset, the average number of trades in a round, the standard deviation of the number of assets across traders, and the range of the number of assets across traders. The final column gives significance levels of Mann–Whitney tests for the difference between treatments with the 10 experimental sessions as units of observations.

	treatment H	treatment L	p-value
Asset Value	58.0	48.0	0.55
Trades per round per trader	2.23	2.18	1.00
Standard deviation of number of assets	2.54	2.31	0.22
Range of number of assets	6.33	5.88	0.10

The third row of Table II indicates that these standard deviations are almost identical for the sessions in treatment H and for those in treatment L. Also, the average range of final number of assets held is similar across the two treatments. Typically, in each session there is at least one trader that sells all three of his or her initial assets, and a trader that buys as many assets as he or she can afford, giving a range of allocations of about six. The range is somewhat larger in treatment H, since the prices of the assets are on average somewhat lower. Some traders manage to buy four additional assets with their initial money endowment of 200 cents.

In conclusion, prices of the risky asset are significantly higher when the market induces traders to evaluate the financial consequences in a more aggregated way, that is, over a longer period of time.

III. Discussion

There is one empirical fact in our data that seems incongruous with myopic loss aversion, namely, the average price of the asset in treatment L is above its expected value of 50. This suggests that subjects are risk seeking, whereas loss aversion, at least in the simple representation that we advanced above, implies risk aversion. An observation of asset prices above their expected value is quite common in experimental markets, however. For example, Knez, Smith, and Williams (1985) find an average price of about 1.40 for a one-period asset with an expected value of 1.25. Similar degrees of "overpricing" are reported in Rietz (1998) and Weber, Keppe, and Meyer-Delius (2000). The simple explanation that subjects are risk seeking fails on a number of accounts. Several other explanations have been advanced. One possibility is the presence of an endowment effect, which makes traders more reluctant to sell than they would be on the basis of a strict evaluation of financial gains and losses. As noted by Weber et al., predictions will depend largely on whether cash endowments and asset endowments are coded jointly or separately and on the location of the reference point(s).

Another possibility is that traders attach some value to the excitement of owning an asset (see Conlisk, 1993). Such a "utility of gambling" would also have an upward effect on prices. Yet another possibility is that some traders are overconfident in predicting the asset's realization, and put too much weight on the probability that the asset will realize a positive value (see Barber and Odean, 2001). In this paper, we cannot and do not wish to argue for or against any of these factors. They simply underline that we do not have a generally accepted or parsimonious behavioral theory of financial decision making.

One explanation for equilibrium prices exceeding the expected value of the assets may lie in the so-called house money effect. In an experiment described in Thaler and Johnson (1990), it is shown that when faced with sequential gambles, people are more risk taking if they earned money on prior gambles than if they lost. The fact that we give subjects money to gamble with could have a similar effect. The interpretation given by Thaler and Johnson is that losses are less painful to people when occurring after a gain than when occurring after a loss.

Barberis, Huang, and Santos (2001) recently used the house money effect in constructing a model of asset prices in which investors derive utility not only from consumption but also from fluctuations in the value of their financial wealth. Their model helps explain the high mean, excess volatility and predictability of stock returns. Some of the ideas in that paper are similar to the model underlying the experiment described in the current paper.

We can investigate the house money effect at the individual level by relating realized profits in the previous round to expenditures on the assets in the current round. Profits are equal to the difference between realized value and price paid of all assets bought plus the difference between price received and value realized of all assets sold. We find a significant positive effect of lagged profits on asset expenditures. Traders who have positive profits from trades in the previous round are more likely to buy assets (and less likely to sell) than traders who had a loss in the previous round. These results are in line with the results obtained by Thaler and Johnson (1990).

As noted above, the average realized asset value was a bit higher in treatment *H* than in treatment L. If the house money effect leads to more risk taking, this would tend to increase the price in treatment *H*. Since we find that the prices are significantly lower in treatment *H*, the house money effect cannot explain the price differentials across treatments.

IV. Conclusion

The main question investigated is whether the frequency of information feedback and the flexibility of portfolio adjustment affect asset prices. Our experimental results provide strong evidence that more information feedback and more flexibility reduce the price of a risky asset. These results are in line with the findings from individual decision-making experiments. They illustrate that intertemporal framing effects matter, not just for individual decision making, but also in market settings.

We find the direction of the price effect is in line with the prediction from myopic loss aversion, and is counter to the one from expected utility theory. At the same time, MLA can only be a first step towards a behavioral theory of intertemporal framing issues in financial decision making. For example, the overpricing that others and ourselves have observed is not easy to explain. Yet, our finding that the framing issues do not simply disappear in a competitive environment strengthens the importance of this ongoing debate.

The economic significance of the phenomena studied here should be evident. The equity premium puzzle or the communication strategies of funds managers (like Bank Hapoalim, mentioned in the introduction) are only two of the many examples where risk taking, flexibility, and information provision interact. Other examples include the trade-off between flexibility and interest paid on bank deposits, the risk profile of individual portfolios, or the choice of investment projects. The fact that the nature of the interaction between risk taking, flexibility, and information provision is different from what received economic theory would predict affects both economic analysis and financial advice based on these models.

The decisions by investors to consult and assess market information will be affected by the availability and cost of such information. If market information becomes available more widely and at lower cost—which arguably is the case in recent years—we can expect it to be used more often. Our results suggest that, ceteris paribus, this may make risky assets less attractive and thus reduce their relative price.

Appendix: Instruction

(Translation from Dutch, with Text for Treatment L in Square Brackets)

This is an experimental study of market decision making. The instructions are simple and if you follow them carefully, you may earn a considerable amount of money. The money you earn will be paid to you, privately and in cash, immediately after the experiment. We will first go through the instructions together. After that, you will have the opportunity to study the instructions at your own pace, and to offer questions. Then we will have a practice round, before we start the experiment.

A. *The Market*

In a few moments, you will be a trader in a market. The market will consist of 15 successive rounds. In the market there will be trading in so-called "units" (of a virtual security). These units all have the same value. This value, however, will be determined and announced only at the end of the round, after the trading has stopped. With a chance of $\frac{1}{3}$ (33 percent) the value of each unit will be Dfl. 1.50 (150 cents), and with a chance of $\frac{2}{3}$ (67 percent) this value will be equal to Dfl. 0.00 (0 cents). How this value is determined will be explained later.

At the beginning of each round, you will start with a certain starting portfolio, which consists of a number of units and a cash balance. Every participant knows

her or his own starting portfolio, but not that of the other participants. Your starting portfolio may be identical to that of other participants, but it may also be different. However, your starting portfolio will be identical in each of the 15 rounds.

As soon as a round has started, you can try to sell units, or you can try to use your money balance to buy units. If you sell a unit, the price you receive will be added to the cash balance in your portfolio and the number of units in your portfolio will be reduced by one. If you buy a unit, the price you pay will be deducted from the cash balance in your portfolio and one unit will be added to your portfolio.

Your earnings in a round are equal to the cash balance in your starting portfolio + the prices you receive for units sold − the prices paid for units bought + the number of units in your portfolio at end of round × value per unit (0 or 1.50).

B. Buying and Selling

Buying and selling of units on the market will be processed by means of the computer. All relevant information will be available on your computer screen. You can now see what this screen will look like.

In the top left, you can see what your total earnings are up to the present. Also you can see the number of the round we are in and the time left for trading in that round. In each round the total time for trading is three minutes [four minutes].

In the middle part of the screen, you will see two columns with the current offers and bids. Each offer price in the column indicates that someone is prepared to sell one unit at that price. Each bid price in the column indicates that someone is prepared to buy one unit at that price. Both offer and bid prices will be ordered from high to low. Your own offer and bid prices are indicated with an asterisk.

If you want to buy a unit, you can do two things. (i) You can press *P* (purchase). You then buy one unit at the lowest offer price that is in the column at that moment. (ii) You can press *B* (bid) and enter a bid price at which you are prepared to buy a unit. If your bid price is the highest in the column, then there will be a chance that someone is prepared to sell at that price and will accept your bid price.

Also if you want to sell a unit you can do two things. (i) You can press *S* (sell). You then sell one of your units at the highest bid price that is in the queue at that moment. (ii) You can press *O* (offer) and enter an offer price at which you are prepared to sell one unit. If your offer price is the lowest in the column, then there will be a chance that someone is prepared to buy at that price and will accept your offer price.

At the bottom of the screen you see a row in which the prices of all the units traded will be indicated, so everyone can see how many units have been traded up to that point and at what prices. However, you cannot see which participants have bought or sold units.

The box on the right of your screen displays information about your portfolio. At the top, your starting portfolio is indicated, consisting of a cash balance and a

number of units. Then you see a list of the units that you have bought or sold and at what price. At the bottom of the box you can see what your current portfolio looks like. Each time you sell a unit, the price is added to your money cash and one unit is deducted from your portfolio. Each time you buy a unit, the price is deducted from your cash balance and one unit is added to your portfolio.

C. Restrictions

You can buy and sell as many units as you want. There are a number of restrictions, however.

  (i)   You cannot sell a unit if your portfolio no longer contains any units.
  (ii) You cannot buy a unit if your cash balance does not suffice to pay the price.
  (iii) When buying units, you cannot use money that you have earned in previous rounds.
  (iv) You cannot withdraw offer and bid prices once they are entered!
  (v)   If you want to enter a new bid price, then it must be higher than your previous bid price. If you want to enter a new offer price, then it must be lower than your previous offer price.

[Finally, there is the following important restriction. Although the experiment consists of 15 rounds, there will be trading in rounds 1, 4, 7, 10, and 12 only. By buying and selling units in a round with trading, you determine your portfolio for that round, but also for the subsequent two rounds. In other words, you always fix your portfolio for three rounds. This means that your portfolio at the end of round 1 (consisting of a cash balance and a number of units) will be identical to your portfolio at the end of round 2 and round 3. In rounds 2 and 3, there will be no trading. This means that if you buy (or sell) a unit at a given price in round 1, you also buy (or sell) a unit at that same price in rounds 2 and 3. Thereafter, your trading in round 4 determines your portfolio in rounds 4, 5, and 6. And the same will happen for rounds 7-8-9, 10-11-12, and 13-14-15. However, the value of the units (0 or 1.50) will be determined separately for each round, also within each block of three rounds.]

D. The Value of the Units

At the end of a round, each unit has the same value. After the time for trading is over, this value will be determined as follows. The assistant has a can with three disks. Two of the disks are black; one is white. At the end of the round, the assistant will first fill the can with the three disks, and then randomly draw one disk. If the disk drawn is black (chance $\frac{2}{3}$), then the value of all units in that round is 0; if the disk drawn is white (chance $\frac{1}{3}$), then the value of all units in that round is 1.50. Your earnings in a round will thus be equal to the cash balance in your portfolio at the end of the round plus the total value of the units in your portfolio.

[As explained, in a trading round, you fix your portfolio for the next three rounds. Therefore, at the end of the trading round, three times the assistant will draw a disk from a can containing two black disks and one white disk. The colors

of the three disks drawn determine the values of the units in the three rounds, respectively. Each white disk drawn implies that in one of the three rounds the value of the units is 1.50; each black disk drawn implies that in one of the three rounds the value of the units is 0.]

E. Summary

The experiment consists of 15 rounds. In each round you start with a portfolio consisting of a given number of units and a given cash balance. You can alter your portfolio by buying and selling units. You can try to buy units by entering a bid price (press *B*) and sell units by entering an offer price (press *A*). Also you can buy by accepting the lowest offer price (press *P*) and you can sell by accepting the highest bid price (press *S*).

[The market is open for trading only in rounds 1, 4, 7, 10, and 12. If you buy or sell a unit in one these five rounds, then you also buy or sell a unit in the subsequent two rounds. Hence, you always fix your portfolio for three consecutive rounds.]

All units have the same value in a round. With a chance of $\frac{1}{3}$ (33 percent), this value is equal to 1.50 and with a chance of $\frac{2}{3}$ (67 percent), this value is equal to 0. This value is determined at the end of the round when the assistant draws one disk from a can containing one white and two black disks.

The total value of the units in your portfolio is added to the cash balance in your portfolio and determines how much you earn in that round. At the end of the experiment, your earnings per round are added and determine how much you earn for your participation.

F. Final Remarks

At the end of today's meeting, you will be called by your table number to collect your earnings one by one. Your earnings are your own business; you do not have to discuss them with anyone.

Talking or communicating with other participants in any way during the experiment is not allowed. If you have a question, please raise your hand and I will come to your table to answer your question. If you have any remarks about the experiment or about your decisions, please use the form labeled "REMARKS" that is on your table

B = enter a Bid price	*P* = Purchase at lowest offer price
O = enter a Offer price	*S* = Sell at highest bid price

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REFERENCES

Barber, Brad, and Terrance Odean, 2001, Boys will be boys: Gender, overconfidence, and common stock investment, *Quarterly Journal of Economics* 116, 261–292.

Barberis, Nicholas, Ming Huang, and Tano Santos, 2001, Prospect theory and asset prices, *Quarterly Journal of Economics* 116, 1–53.

Barron, Greg, and Ido Erev, 2000, On the relationship between decisions in one-shot and repeated tasks: Experimental results and the possibility of general models, Mimeo, Technion.

Benartzi, Shlomo, and Richard Thaler, 1995, Myopic loss aversion and the equity premium puzzle, *Quarterly Journal of Economics* 110, 73–92.

Camerer, Colin, 1992, The rationality of prices and volume in experimental markets, *Organizational Behavior and Human Decision Processes* 51, 237–272.

Conlisk, John, 1993, The utility of gambling, *Journal of Risk and Uncertainty* 6, 255–275.

Enke, Stephen, 1951, On maximizing profits: A distinction between Chamberlin and Robinson, *American Economic Review* 41, 566–578.

Forsythe, Robert, Forrest Nelson, George Neumann, and Jack Wright, 1992, Anatomy of an experimental political stock market, *American Economic Review*, 82, 1142–1161.

Gneezy, Uri, and Jan Potters, 1997, An experiment on risk taking and evaluation periods, *Quarterly Journal of Economics* 102, 631–645.

Gollier, Christian, John Lindsey, and Richard Zeckhauser, 1997, Investment flexibility and the acceptance of risk, *Journal of Economic Theory* 76, 219–241.

Kahneman, Daniel, and Amos Tversky, 1979, Prospect theory: An analysis of decision under risk, *Econometrica* 47, 263–291.

Knez, Peter, Vernon Smith, and Arlington Williams, 1985, Individual rationality, market rationality, and value estimation, *American Economic Review* 75, 397–402.

Langer, Thomas, and Martin Weber, 2001, Prospect theory, mental accounting and differences in aggregated and segregated evaluation of lottery portfolios, *Management Science* 47, 716–733.

Langer, Thomas, and Martin Weber, 2002, Myopic prospect theory vs. myopic loss aversion: Does myopia always hurt? Mimeo, University of Mannheim.

Mehra, Rajnish, and Edward Prescott, 1985, The equity premium: A puzzle, *Journal of Monetary Economics* 15, 145–161.

Rietz, Thomas, 1998, Enforcing arbitrage restrictions in experimental asset markets, Mimeo, University of Iowa.

Thaler, Richard, and Eric Johnson, 1990, Gambling with the house money and trying to break even: The effects of prior outcomes on risky choice, *Management Science* 36, 643–660.

Thaler, Richard, Amos Tversky, Daniel Kahneman, and Alan Schwartz, 1997, The effect of myopia and loss aversion on risk taking: An experimental test, *Quarterly Journal of Economics* 102, 647–661.

Tversky, Amos, and Daniel Kahneman, 1992, Advances in prospect theory: Cumulative representation of uncertainty, *Journal of Risk and Uncertainty* 5, 297–323.

Weber, Martin, Hans-Jurgen Keppe, and Gabriela Meyer-Delius, 2000, The impact of endowment framing on market prices—An experimental analysis, *Journal of Economic Behavior and Organization* 41, 159–176.